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SPATIAL DISTRIBUTION OF LUMBER DEGRADE IN WHITE FIR TREES

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ABSTRACT

The spatial distribution of lumber degrade was determined and analyzed in 20 white fir trees. A general pattern of increasing degrade from pith to bark in the radial direction was observed. In the vertical direction, degrade initially decreased and then increased with height.

Results suggest that both the grade of the lumber from a given location in the tree and the uniformity of that lumber with respect to the drying sort material (sinker, sap, or corky) can affect the magnitude and pattern of degrade in white fir.

This study suggests that decreased degrade might result if additional drying sorts were made in the current sap and sinker sort. This study also indicates that wetwood, by itself, previously considered to be a source of lumber drying problems, has little or no effect on degrade.

KEYWORDS: Lumber recovery studies, white fir, lumber grading, seasoning.

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CONTENTS

INTRODUCTION

Lumber degrade has been the subject of numerous investigations concentrated mainly in the phenomenon of processing logs to lumber, with little attention being given to degrade relative to the tree.

Research in the drying of white fir has touched on the degrade-tree relation when it recognized the need for sorting white fir lumber prior to drying (Smith and Dittman 1960a, 1960b). In these studies the primary emphasis was on the drying process, particularly with relation to moisture content and drying time. Recent investigations on wood of white fir (Wilcox 1968, Wilcox and Pong 1971) have shown the properties of the wetwood portion to be comparable to those found elsewhere in the tree. The slower drying rate associated with wetwood has been attributed in part to the higher density and lower diffusion coefficient of this wood (Arganbright and Wilcox 1969).

The effects of certain pathological defects on lumber grade yield and lumber degrade have also been studied. Differences in recovery of certain grades of white fir lumber were found to be associated with logs infected with dwarf mistletoe; there were, however, no apparent effects of this defect on lumber degrade (Wilcox et al. 1973). In red oak, bacterial-infected wood was found to be more susceptible than noninfected wood to honeycomb and ring failure (Ward et al. 1972), both of which are lumber degrading factors.

Results from the foregoing studies suggest that many of the degrade problems associated with lumber drying have their origin in the raw material and not in processing. Identifying in the trees the troublesome locations producing lumber potentially high in degrade would allow processors greater flexibility in coping with the problem.

In white fir, in particular, the problem of lumber degrade appears to be closely associated with location in the tree; however, data to substantiate this or to indicate these locations had never been collected. In conjunction with a larger study (Pong 1971, Wilcox and Pong 1971) on wood properties and lumber quality in white fir, it was possible to collect data on the degrade of white fir lumber relative to its location in the tree. This paper reports the results of that portion of the study dealing with the distribution of lumber degrade in white fir trees.

MATERIALS AND METHODS

Twenty white fir (*Abies concolor* (Gord. and Glend.) Lindl.) trees, representative of the range of diameters and heights of trees commonly logged in the area (see table 1), were selected for the study from a single stand of mixed conifers in El Dorado County, California. The selection area was located on the west side of the Sierra Nevada at an elevation of 6,200 feet. The relatively young stand on a good site was predominately a white fir/incense-cedar/sugar pine timber type.

Surface characteristics of each tree to be logged were diagramed (Jackson et al. 1963, Pong and Jackson 1971), and other important details of the tree and surrounding area were noted and recorded. The identity of each tree was maintained throughout the study with an assigned number. After felling and bucking, tags containing the identifying tree and log numbers were stapled on the ends of each log so that the log's position in the standing tree would remain known throughout processing. A net scale of 50 percent or more of gross scale was required of all study logs. Logs were graded by using a system of three grades (Wise and May 1958): Select (grade 1), Shop (grade 2),

Table 1.--*Distribution of size and age of white fir study trees*

Tree number	D.b.h.	Total height	Age[1/]
	Inches	*Feet*	*Years*
1	24.3	100	143
2	23.8	97	95
3	46.2	142	141
4	46.4	182	150
5	18.6	99	145
6	21.2	110	145
7	21.5	104	83
8	17.2	94	79
9	28.0	137	147
10	29.8	139	139
11	37.4	158	144
12	38.1	160	143
13	24.9	115	98
14	20.7	92	94
15	20.1	88	130
16	32.4	156	149
17	46.9	175	169
18	39.2	165	176
19	40.7	168	146
20	37.1	129	109

[1/] At stump height.

and Common (grade 3).[1/] Log lengths taken varied from 10 to 20 feet (table 2) and diameters, from 10 to 39 inehes (table 3).

Prior to sawing, the large end of each log was painted in a target pattern with three eolors; eaeh band of eolor covered approximately one-third of the log radius. The paint eolor on the ends of the resulting boards delineated, to the nearest third of the radius, the radial position within the log from whieh the board had eome.

[1/] Logs in the Common grade include both high and low Commons.

Table 2.--*Distribution of study logs by length and log grade*

Log length (feet)	Log grade[1/]			
	1	2	3[2/]	All grades
	- - - - - *Number* - - - - -			
10	0	0	10	10
12	0	0	9	9
14	0	1	3	4
16	8	11	67	86
18	0	0	2	2
20	0	0	1	1
Total	8	12	92	112

[1/] See Wise and May (1958).

[2/] Logs in this grade include high and low Commons.

Table 3.--*Distribution of study logs by diameter class and log grade*

Diameter inside bark (inches)	Log grade[1/]			
	1	2	3[2/]	All grades
	- - - - - *Number* - - - - -			
9.6 - 12.5	0	0	15	15
12.6 - 15.5	0	3	15	18
15.6 - 18.5	0	3	15	18
18.6 - 21.5	0	0	9	9
21.6 - 24.5	1	1	15	17
24.6 - 27.5	1	1	11	13
27.6 - 30.5	3	2	4	9
30.6 - 33.5	2	0	4	6
33.6 - 36.5	0	2	4	6
36.6 - 39.5	1	0	0	1
Total	8	12	92	112

[1/] See Wise and May (1958).

[2/] Logs in this grade include high and low Commons.

Each log was sawn with the intent of recovering the optimum value through manufacture of usual lumber items. Sawing practice during the study period conformed to general industry practice in the west-side Sierra and was geared to produce Select, Shop, Common, and Dimension lumber. All lumber was sawn to meet Western Wood Products Association specifications. All material cut from a given log was color-coded at the headsaw as the log was initially broken down. From this code, crewmembers numerically identified each board with the appropriate number of the log from which the board was sawn. On the green chain each board was stamped consecutively with a number, marked for drying sort by mill personnel, and then graded by a certified grader. Trimming of lumber at all stages in the study was by pencil only; actual trimming of the study lumber was not done until after it was surfaced and graded.

It was the practice of the mill where the study was performed to segregate the green lumber into three drying sorts (sap, corky, and sinker) (Smith and Dittman 1960a) for each of four thicknesses (4/4, 5/4, 6/4, and 7/4). A fourth sort (4- by 4-inch Dimension) called "No. 4" or dunnage was cut from the shaky cores. Normally there is no green grading of the white fir lumber by the mill. Study lumber was not tallied in the green condition except for the No. 4 and all of the 4/4 lumber; these were hand-tallied by board number, mill log number, green grade, width, length, and thickness. Since there was to be no further processing of the dunnage and the 4/4 lumber, we assumed the green grade of this lumber would have held true if dried and surfaced. The remainder of the lumber was tallied after kiln drying.

Modern, single track, internal fan, cross-circulation kilns were used to dry the study lumber. For each of the three basic drying sorts, a different kiln charge and schedule were used (table 4). Each schedule gives a 5- to 10-percent redry and an average moisture content of 15 to 16 percent, with a maximum moisture content of 19 percent.

After drying, the lumber was sorted for surfacing on the dry sort chain. During dry sorting, a photographic record of each board was made on color film using a cinepulse camera triggered by an automatic photo-electric pulser (Pong et al. 1970). The film record for each board contained the end color code, sequential board number, log number, drying sort, green and rough-dry grades, pencil trim, defects and other surface conditions, width, length, and thickness (fig. 1). Each board was also tallied by hand to show green and dry grades, any pencil trimming, board and log numbers, length, width, and thickness.

Rough-dry Dimension lumber was surfaced on four sides and Selects and Shops, on two sides. Boards entering the planer were recorded on data sheets by the numbers originally stamped on the green chain. As each board left the planer, it was graded, pencil trimmed, and a consecutive number written on its surface. This number coincided with the number of entries made on the data sheets on the infeed side of the planer. Each surfaced board was then photo-recorded on color film.

DATA PROCESSING AND ANALYSES

Hand-tallied data for rough-green and rough-dry boards were edited and corrected using the photographic record made on the dry sort chain. The tally of consecutive numbers made at the infeed side of the planer was matched and

Table 4.--*Dry kiln schedules for sap, sinker, and corky white fir lumber, American Forest Products Corporation, Martell, California*

Timespan (hours)	Temperatures		
	Dry bulb	Wet bulb	Wet bulb depression
	- - - - - - - - - *Degrees F*	- - - - - - - - - - -	
Sap:			
0-36	160	140	20
37-76	170	140	30
77-100	180	140	40
101-106 conditioning	--	--	--
Total time: 106 hours	--	--	--
Sinker:			
0-24	160	140	20
25-60	170	140	30
61-168	180	140	40
169-174 conditioning	--	--	--
Total time: 174 hours	--	--	--
Corky:			
0-24	160	140	20
25-54	170	140	30
55-60 conditioning	--	--	--
Total time: 60 hours	--	--	--

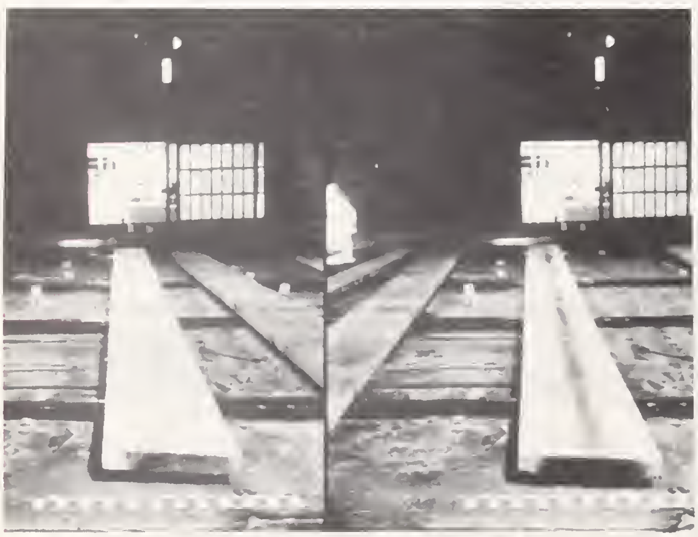

Figure 1.--Consecutive frames from the photographic record made on the dry sort chain during sorting of white fir study lumber.

corrected with the rough-green and rough-dry board tallies. The board data for the surfaced lumber were then transferred from the film record of the surfaced lumber to the data sheets containing the consecutive board numbers.

The radial location of each study board in the log was determined by visually rating to the nearest 10 percent the percentage of its end area occupied by each of the radial position color codes. To insure accuracy, two independent ratings were made on all boards.

Data for each phase of the study were transferred from tally sheets to punched cards. A detailed matching of the card data was then made for each board in rough-green, rough-dry, and surfaced-dry condition. Board cards were segregated prior to processing into four radial groups of end color codes: center, middle, outer, and mixed. Boards with end codes of two colors were placed in the first three radial groups (see table 5). Boards with codes of three colors were placed in the fourth group, since the radial origin of these boards was not readily discernible. The cards were analyzed by automatic data processing for grade and volume change after each stage of processing (Pong 1971) for various combinations of log position, radial segregation, log grade, and drying sort. Common grades of lumber, i. e., 2, 3, and 4 Common, were combined with the Dimension grades of Standard, Utility, and Economy, respectively.

The percent of lumber that degraded--i. e., downgraded one or more grades after each processing stage and segregated by radial location and vertical position in the tree--was analyzed by analysis of variance and covariance. Log diameter and percent log defect were selected as covariates in the analyses.

Table 5.--*Board end color code combinations included in each radial segregation of study lumber*

Board end color[1/]	Radial segregations																				
	Center							Middle							Outer						
	Percent																				
Black	100	90	80	70	60	50	40	30	20	10											
Yellow		10	20	30	40	50	60	70	80	90	100	90	80	70	60	50	40	30	20	10	
Green												10	20	30	40	50	60	70	80	90	100

[1/] Colors are listed with increasing distance from pith.

RESULTS

The 112 logs included in this study produced over 43,000 board feet of lumber. The volume of lumber in each of the radial segregations for each stage in processing is presented in table 6. Differences in volume in a given radial segregation represent, in the main, pencil trim "losses" following each processing stage. Boards coded with three colors (the "mixed" segregation) totaled less than 10 percent of the study material.

Table 7 shows the percent degrade occurring in each of four radial segregations of lumber from four log positions after various stages of processing. The radial distribution of degrade for each of four log positions after each processing step is presented in figure 2, and the vertical distribution of degrade for each radial segregation is presented in figure 3. In general, these distributions suggest that degrade increases with distance from the pith at all log positions; for each radial segregation of lumber, degrade initially decreases with height and then increases.

Statistical analysis of the data summarized in table 7 showed that degrade among segregated groups of lumber in the radial direction differed significantly at the 5-percent level in only log positions 1 and 2 when going from the rough-dry to surfaced-dry condition. Vertically, degrade of lumber from different logs in the tree was significantly different at the 5-percent level in only the center radial segregation of lumber when going from the rough-dry to surfaced-dry condition. In these analyses, the "mixed" segregation was not included because of the indeterminate radial origin of the data.

Table 6.--*Radially segregated volumes of study lumber in rough-green, rough-dry, and surfaced-dry condition*

Radial segregation	Lumber condition		
	Rough-green	Rough-dry	Surfaced-dry
	Board feet		
Center	11,763	11,720	11,622
Middle	10,080	10,038	9,899
Outer	17,089	16,990	16,559
Mixed	4,155	4,157	4,101
Total	43,087	42,905	42,181

Table 7.--*Amount of degrade occurring in each of four radially segregated groups of white fir lumber from four log positions after each stage of processing*

Radial segregation	Log position[1/]				
	1	2	3	4+	All
	- - - - - - - - - - *Percent* - - - - - - - - - -				
Rough-green to rough-dry:					
Center	12.0	6.6	13.9	14.5	12.3
Middle	23.8	12.7	10.3	12.7	15.7
Outer	22.1	16.9	19.9	21.4	20.2
Average, three segregations	19.4	13.2	16.1	17.1	16.7
Mixed	35.1	13.2	4.5	15.2	16.0
Average, all segregations	20.5	13.2	14.6	16.9	16.6
Rough-dry to surfaced-dry:					
Center	25.9	45.8	31.9	34.8	34.1
Middle	43.0	32.1	26.4	38.5	36.9
Outer	46.3	40.8	39.9	36.2	39.1
Average, three segregations	38.6	40.0	34.6	36.3	37.4
Mixed	26.4	8.8	36.7	41.1	33.9
Average, all segregations	37.7	38.3	34.9	36.9	37.0
Rough-green to surfaced-dry:					
Center	30.1	40.9	31.3	36.4	34.6
Middle	53.9	33.5	31.1	44.5	43.3
Outer	54.6	45.7	46.2	47.1	48.0
Average, three segregations	46.5	41.2	38.5	43.2	42.8
Mixed	44.2	15.4	39.8	46.8	41.2
Average, all segregations	46.3	39.8	38.7	43.6	42.5

[1/] Log position in 16-foot log lengths from the butt.

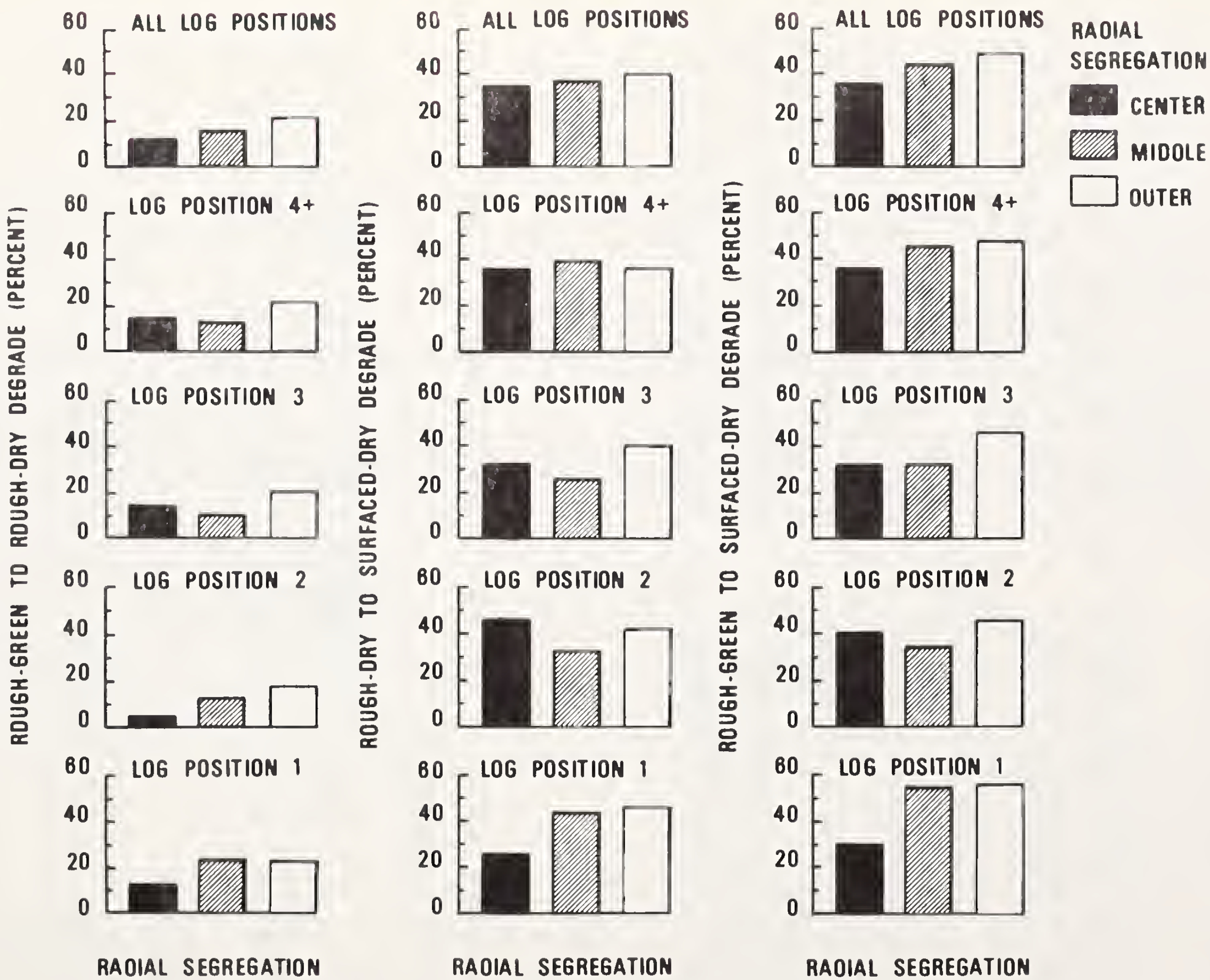

Figure 2.--Radial distribution of lumber degrade at various heights in white fir trees--rough-green to rough-dry, rough-dry to surfaced-dry, and rough-green to surfaced-dry condition. Log position is in 16-foot lengths from the butt.

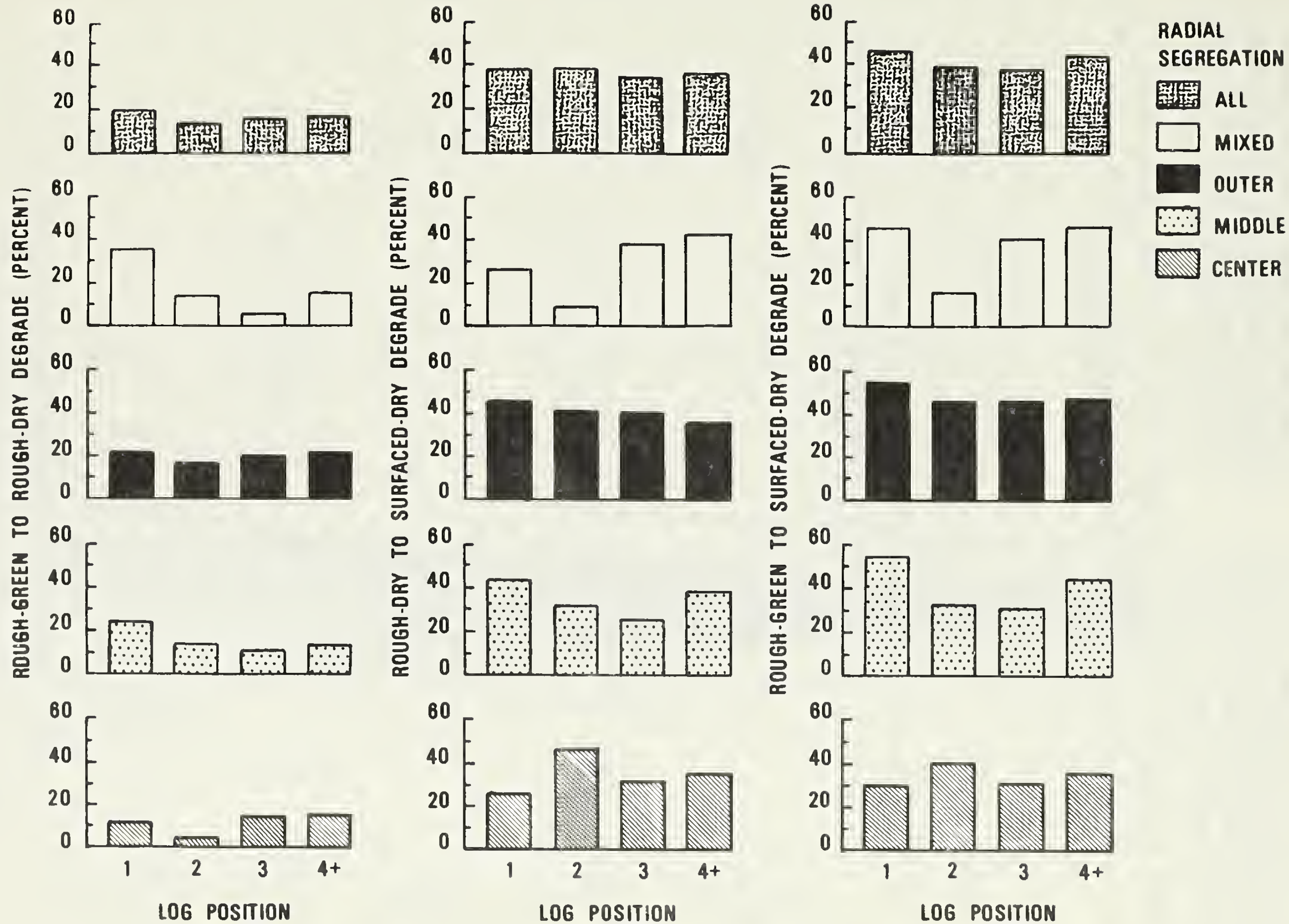

Figure 3.--Vertical distribution of lumber degrade of various radial segregations in white fir trees--rough-green to rough-dry, rough-dry to surfaced-dry, and rough-green to surfaced-dry condition. Log position is in 16-foot lengths from the butt.

Table 8 presents the degrade of three drying sorts of lumber, each from four log positions. Commercially the sorts are indicative of the time required to kiln-dry lumber, with the corky sort requiring the shortest period, followed by the sap sort, and then the sinker sort (see table 4). The corky sort, which we found to come primarily from above the third log and radially from the center and

Table 8.--*Amount of degrade occurring in each of three drying sorts of white fir lumber from four log positions after each stage of processing*

Log position[1/] and drying sort	Processing stage		
	Rough-green to rough-dry	Rough-dry to surfaced-dry	Rough-green to surfaced-dry
	- - - - - -	*Percent*	- - - - - -
1:			
Sinker	15.4	38.0	43.5
Corky	[2/]0	[2/]0	[2/]0
Sap	22.2	44.2	63.8
Average	20.5	37.7	46.3
2:			
Sinker	12.0	36.4	38.8
Corky	[2/]66.7	[2/]0	[2/]66.7
Sap	16.7	44.1	46.2
Average	13.2	38.3	39.8
3:			
Sinker	18.5	36.2	42.0
Corky	2.3	16.3	16.3
Sap	13.1	41.3	43.3
Average	14.6	34.9	38.7
4+:			
Sinker	20.6	35.2	48.7
Corky	13.1	39.3	43.0
Sap	18.7	39.6	50.1
Average	16.9	36.9	43.6
All log positions:			
Sinker	15.0	37.0	42.0
Corky	11.6	36.0	39.2
Sap	17.2	40.8	48.4
Average	16.6	37.0	42.5

[1/] Log position in 16-foot lengths from the butt.

[2/] Degrade based on a drying sort volume of less than 100 board feet of lumber.

middle thirds (Wilcox and Pong 1971) (fig. 4), degraded less than either the sap or sinker sorts in all stages of processing except during the rough-dry to surfaced-dry stage, when this sort from the fourth and higher logs registered a higher degrade than the sinker sort. The sap sort registered higher degrade than the sinker sort at all stages of processing except during the rough-green to rough-dry stage, when the sinker sort from the third log and above showed a higher degrade.

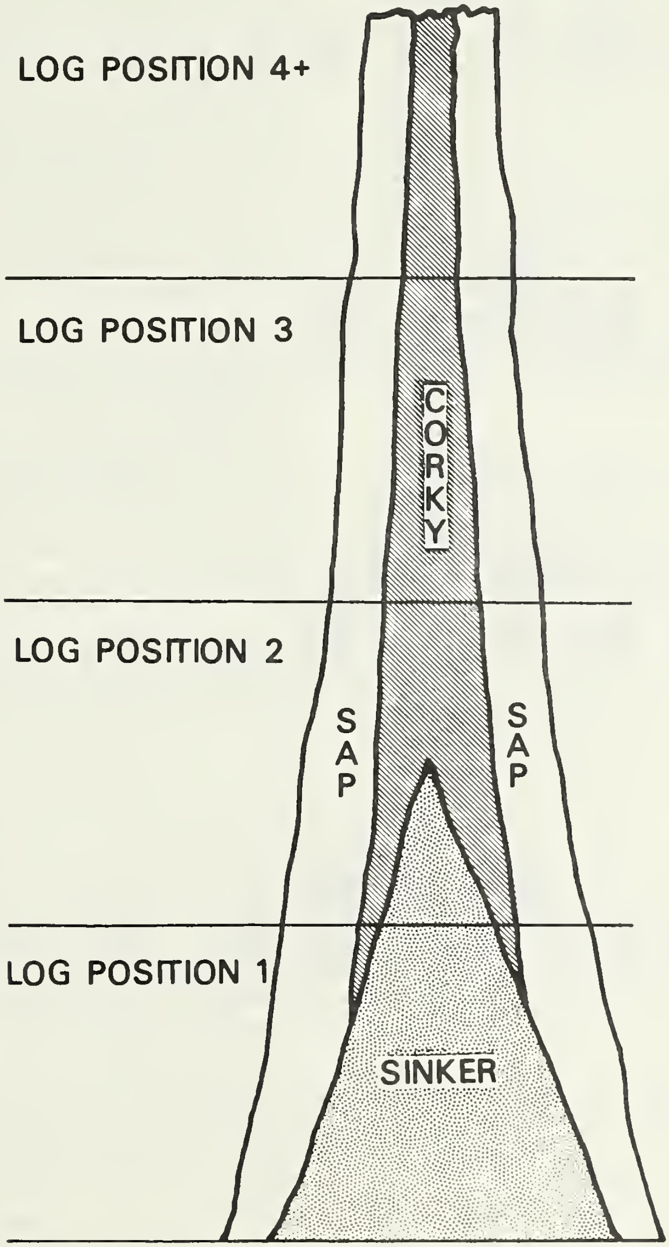

Figure 4.--Graphic representation of distribution of drying sorts in white fir trees, based upon earlier data (Wilcox and Pong 1971), mill observation, and statements of mill personnel. Log position is in 16-foot lengths from the butt.

The degrade of lumber from different grades of logs after each processing step is presented in table 9. All grade 1 logs were butt logs (log position 1) except for one second log (log position 2); grade 2 logs were composed of butt and second logs, and grade 3 logs were a mixture of logs from all positions. In general, lumber from grade 1 and 2 logs degraded more than the lumber from grade 3 logs. Since the logs in grades 1 and 2 included a substantial number of high quality, position 1 logs, it is understandable that the recorded lumber degrade for these grades of logs was similar to that recorded for position 1 logs, while the grade 3 logs, being a composite of logs from all log positions, averaged somewhat lower in degrade than the higher grade logs (table 7).

The recovery of various grades of lumber in the rough-green, rough-dry, and surfaced-dry condition for the four log positions and for the four radial segregations of lumber, respectively, are presented in figures 5 and 6. As expected, the recovery of higher grades of lumber (Selects and Shops) was proportionately greatest from lower logs (fig. 5), with most of the production of these grades concentrated in the outer radial segregation (fig. 6). The recovery of Dimension grades of lumber, though proportionately less in the lower logs than upper logs, still made up the bulk of the lumber volume from all logs. In the upper logs, the recovery was almost entirely in the Dimension grades (fig. 5). Radially, the recovery of Dimension lumber was proportionately greatest in the center and middle radial segregations (fig. 6).

In the "mixed" radial segregation, also (fig. 6), the lumber recovery was mostly Dimension. The fact that these boards were color coded with three colors suggests that they were sawn from logs of small diameter. Our data indicate that most of these boards were from the small diameter, upper logs of the study.

Table 9.--*Amount of degrade occurring in white fir lumber sawn from different grades of logs after each stage of processing*

Log grade[1/]	Processing stage		
	Rough-green to rough-dry	Rough-dry to surfaced-dry	Rough-green to surfaced-dry
	- - - - - - - - - - - - *Percent*	- - - - - - - - - -	
1	19.9	40.5	46.8
2	14.7	42.7	46.5
3[2/]	16.4	35.3	41.1
All logs	16.6	37.0	42.5

[1/] See Wise and May (1958).

[2/] Logs in this grade include high and low Commons.

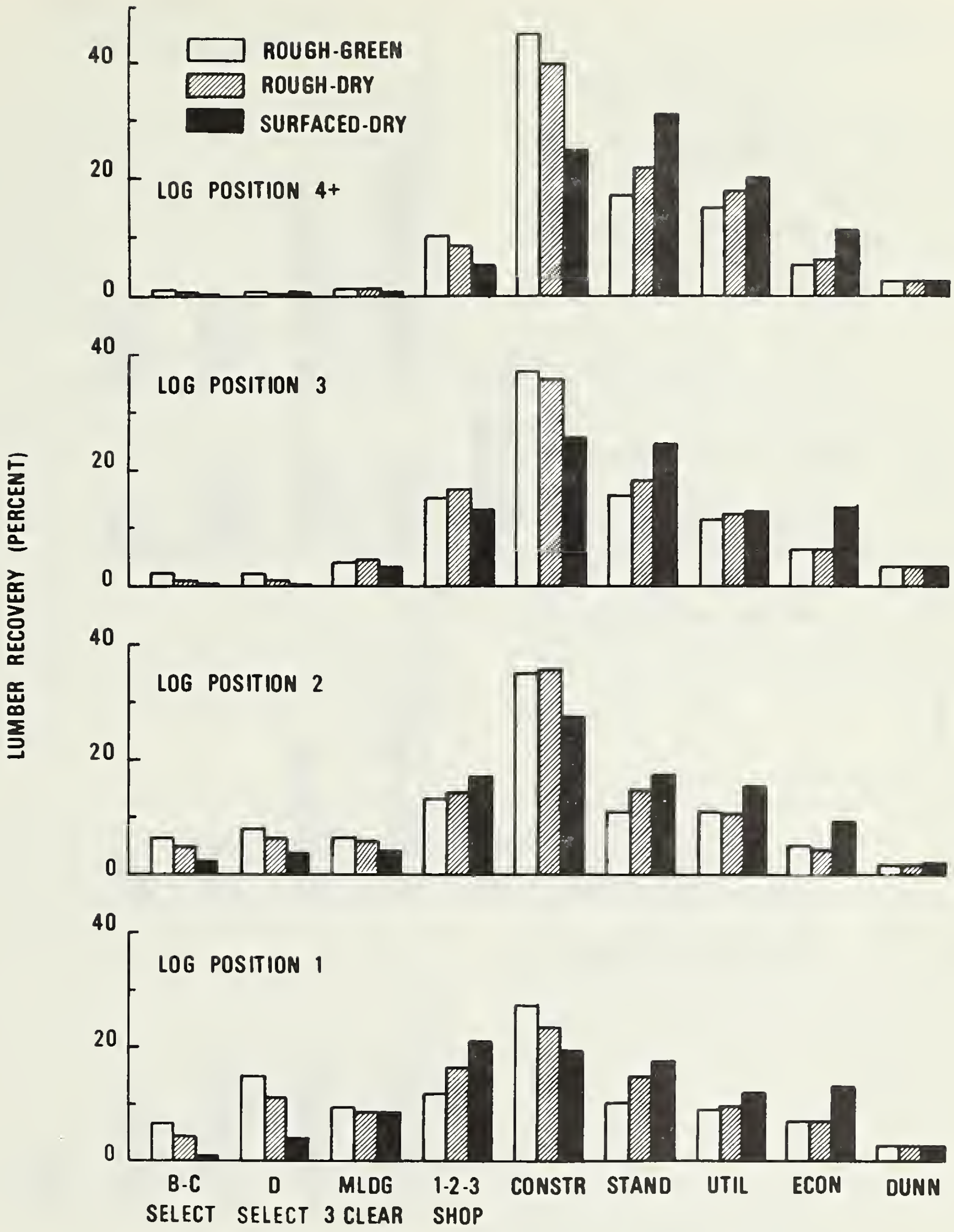

Figure 5.--Grade recovery of white fir lumber for four log positions in the rough-green, rough-dry, and surfaced-dry condition. Log position is in 16-foot lengths from the butt.

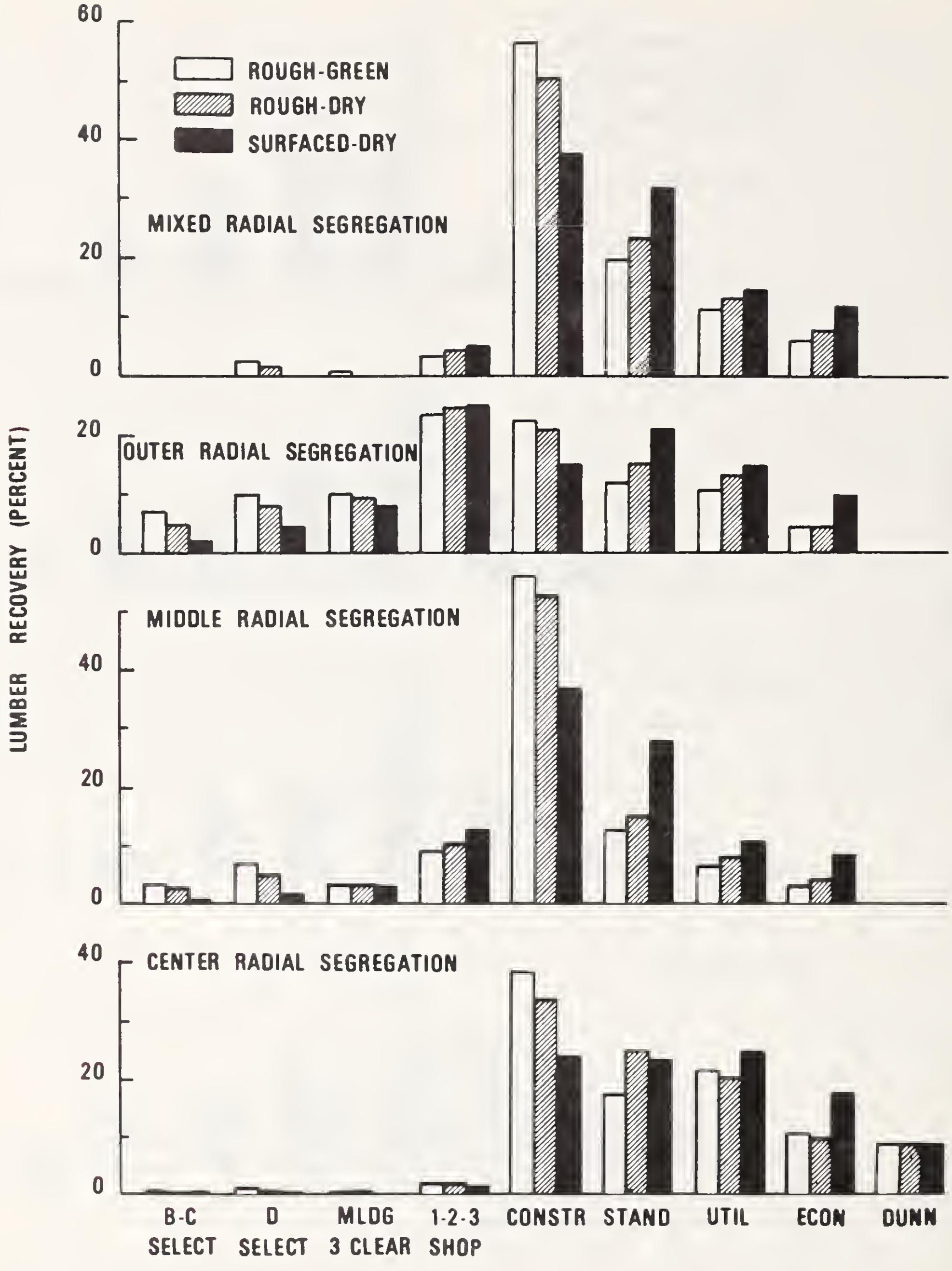

Figure 6.--Grade recovery of white fir lumber for four radial segregations in the rough-green, rough-dry, and surfaced-dry condition.

DISCUSSION AND CONCLUSIONS

We would like to emphasize that the results of this study apply only to the sample tested. Still, it is useful to draw from these data a number of conclusions with regard to the spatial distribution of lumber degrade and grade recovery on the belief that they may be fairly representative of white fir.

Though there was some variation in the degrade distribution pattern of the study lumber from the various log positions and in each of the radial segregations following processing (see table 7; figs. 2 and 3), a general pattern of degrade could be observed in the study trees. This pattern was one of increasing degrade from pith to bark in the radial direction, while in the vertical direction, degrade initially decreased and then increased with height.

The fact that greater degrade was generally recorded in the middle and outer radial segregations of lumber at all log positions following each processing stage suggests that the grade falldown could be due in part to the grade of lumber in these segregations. As previously reported (Pong 1971), higher grades of lumber tend to degrade more than lower grades of lumber due to more stringent grading rules applied to them. Examination of lumber grades recovered in the rough-green, rough-dry, and surfaced-dry condition by log position (fig. 5) shows that the Selects, Shops, and Dimensions all experienced some downward shifting of grade regardless of log position. What proportion these grades were of the total lumber volume for any one radial location, however, could influence the level of degrade at that location. Examination of the lumber recovery in each radial segregation (fig. 6) reveals that nearly all Shops and Selects produced in this study were concentrated in the middle and outer radial segregations.

How uniform each of these segregations is with regard to drying sort may also have an influence on degrade. We found in previous work (Wilcox and Pong 1971) that drying sorts originate from different locations within white fir trees (fig. 4). The bulk of the sinker sort came from the center and middle radial thirds of the lowest two logs, commonly referred to as the wetwood zone (Wilcox 1968). Most of the corky sort came from the center and middle thirds of logs above the third log, and the sap sort came primarily from the middle and outer thirds of the logs above the second log. Such a distribution of drying sorts would suggest that the distribution of degrade, both radially and vertically, could be affected by the uniformity of the dry sort material from each location.

Since each sort requires different times to dry, the problems associated with drying boards in a given sort which contains material that actually belongs in more than one sort would be minimal in those segregations which are most uniform and greatest in those which are not. In actual practice, however, boards must be produced in standard sizes; and it frequently is not possible to saw them so that they contain material which will dry uniformly. Boards composed of material of more than one sort must be dried at the schedule appropriate for the material of the slowest drying rate, with the result that the faster drying material in the same board may be overdried.

According to this logic, the sap sort, which contains material primarily from the outer radial third of logs from all heights in the tree, would be expected to contain the greatest amount of mixed sort material and to have the highest degrade.

Similarly, boards from the center of lower logs (primarily sinker sort) and the center of upper logs (primarily corky sort) would be expected to contain material mostly of a single drying characteristic and, therefore, to have lower degrade than material from other locations. Both hypotheses appear to be borne out by the present data (tables 7 and 8).

Thus, the generally lower degrade registered by the center segregation of lumber (fig. 2) may reflect not only lower lumber grades but also a more uniform sort in this radial group of lumber. The higher degrade of the middle and outer segregations reflects a less uniform sort along with the observed higher grades of lumber in these segregations.

In upper, small-diameter logs there is less chance for boards to be of uniform sort. This may be reflected not only by the overall increase in degrade in the lumber from the fourth and higher logs but also by the relatively higher lumber degrade in each of the radial segregations (fig. 3, table 7) and in each of the drying sorts (table 8).

The fact that a significant difference in degrade was recorded between segregated groups of lumber at log position 1 following the surfacing of the rough-dry lumber (fig. 2) suggests that the lumber in the center segregation at this log position was of nearly uniform sort (sinker). Also suggested is that the middle and outer segregations contained not only pure sap boards but also boards of sinker-sap combination (fig. 4).

The significantly higher degrade registered by the center segregation of lumber at log position 2 in going from the rough-dry to the surfaced-dry condition suggests that this segregation was less uniform in its drying sort not only in comparison to the other radial segregations at that log position (fig. 2) but also when compared to the center segregations of the other log positions (fig. 3). Because logs at this position may contain material of all three drying sorts (fig. 4; also Wilcox and Pong 1971), it can be assumed that the center segregation included not only boards of pure sinker material but also boards of sinker-sap, sinker-corky, and sinker-corky-sap combinations. It is interesting that the degrade of this particular segregation increased nearly sevenfold--6.6 percent to 45.8 percent (table 7)--between the stages of rough-green to rough-dry and rough-dry to surfaced-dry. This was the largest single change in degrade registered by any of the segregations of lumber included in the study.

The lower values of lumber degrade recorded in the middle and outer radial segregations at log positions 2 and 3 suggest greater uniformity in these segregations--corky in the middle, sap in the outer (see fig. 4)--in comparison to those at log position 1 (fig. 3, table 7). They also reflect the exceptionally low degrade of the corky sort (table 8) and the occurrence of lower grades of lumber in these radial segregations (figs. 5 and 6).

It is apparent from our discussion that a lack of uniformity in the composition of individual boards can significantly affect the magnitude and distribution of lumber degrade in white fir trees. Our results suggest that segregated groups of boards containing material of uniform drying properties degrade less than those of less uniform composition. These results confirm those reported by Smith and Dittman (1960b) in their work on drying rates of white fir. If what we suggest here is correct, wetwood, as such, previously considered to be a source of lumber drying problems, has little or no effect on degrade.

The fact that significant differences in degrade were recorded in the lowest two logs places even greater importance on these logs than might at first be recognized. This is true not only because of the potential of these logs for producing the highest quality boards and nearly half the total lumber volume in the tree (Wilcox and Pong 1971) but also because it is in these logs that reducing degrade has its greatest potential, both in volume and value. This is particularly apparent when one realizes that in our sample the lowest two logs generally were the highest quality and produced the greatest quantity of upper grades of lumber, while at the same time producing the greatest amount of degrade (table 9).

Results of this study strongly suggest that decreased degrade might result if additional drying sorts were made in both the sap and sinker sorts. This would allow separation of boards of mixed composition from those of uniform dry sort material. Such a separation would remove boards potentially high in degrade to a smaller group, which could then be dried under a different schedule, hopefully with much less degrade. This would also allow greater flexibility in improving the drying schedules for the residual, more uniform sorts of lumber, which in some cases are the highest quality boards--the sap sort in the lowest two logs.

This study has shown that examining degrade in relation to parameters apparent in standing white fir trees may help to identify within the tree troublesome locations producing lumber potentially high in degrade. Results of this study emphasize the need to recognize that many of our degrade problems may actually have their origin in properties of the raw material rather than being directly caused by processing.

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